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# Effect of topical tranexamic acid on post-traumatic elbow stiffness in patients treated with open arthrolysis: a prospective comparative study

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**Background:** Elbow joint open arthrolysis is an effective method to release contracted tissue and débride heterotopic ossification in cases of post-traumatic elbow stiffness. Recurrence remains one of the most common concerns for surgeons. Soft tissue contracture may result from intra- and/or extra-articular bleeding, edema, effusion, and granulation. The increasing incidence of intraoperative and postoperative bleeding has caused uncertainty about surgical outcomes. Tranexamic acid (TXA) is effective for reducing surgery-related bleeding and effusions in total hip or knee arthroplasty.

**Purpose:** To investigate whether topical TXA can decrease blood loss and effusions in patients treated with elbow joint open arthrolysis and whether it affects final function.

**Patients and Method:** A prospective comparative study was conducted. Sixty-one patients with joint stiffness were enrolled and randomly divided into 2 groups: one consisting of 31 patients treated with topical TXA intraoperatively after open arthrolysis (experimental group) and the other consisting of 30 patients who received saline administration (control group). The operation time, tourniquet time, and intraoperative blood loss were recorded. Drainage volume, elbow rotation, elbow motion arc, Mayo Elbow Performance Score, and operation-related complications were followed up and recorded, whereas hematoma volume remaining in the joint space after drainage tube removal was assessed on ultrasonography.

**Results:** Tourniquet time, intraoperative blood loss, and postoperative drainage were significantly lower in the TXA group than in the control group. However, no significant intergroup differences were found in the incidence of related complications and final function evaluated at the final follow-up.

**Conclusion:** Topical TXA improves surgical quality by controlling intraoperative bleeding, decreases the amount of blood loss soon after surgery, and could become a routine procedure in elbow joint open arthrolysis.

**Level of evidence:** Level II; Randomized Controlled Trial; Treatment Study



**Keywords:** Tranexamic acid; topical; elbow stiffness

Elbow stiffness, which commonly occurs after elbow trauma and surgery, and affects daily activities, has an incidence of close to 12%.[14] An elbow motion arc of 100° is required for satisfactory performance in most daily activities,[13] and loss of elbow motion arc greatly affects quality of life, especially those of young, active individuals.

Approval for this study was received from the Ethics Committee of Shanghai Sixth People's Hospital.

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Open arthrolysis is a promising surgical method for treating elbow stiffness because of its wide range of indications and curative effect. But the occurrence of elbow stiffness remains a common complication.[3,6] Operative exposure and extensive dissection of the soft tissue, bone surface, muscle, and soft tissue oozing after osteophytes; fibrous scar removal; and excessive fibrinolysis in lengthy surgeries are the main causes of excessive bleeding. These may lead to increased intra-articular effusion, thereby affecting the rehabilitation exercise of patients and, finally, their recovery rate and prognosis.[11,1,10] Thus, identification of an efficient way to decrease the risk of perioperative bleeding is important.

As a lysine analog, tranexamic acid (TXA) competitively binds to plasminogen at the fibrin-binding site and acts as an antifibrinolytic to decrease blood loss.[7] TXA is used in patients with acute trauma to decrease overall mortality rates.[5] In elective orthopedic surgery such as spine surgery and arthroplasty, TXA has also been demonstrated to be effective at reducing transfusion rates; importantly, the thrombosis rates did not increase. Besides its ability to reduce blood loss, TXA has been proven to be effective at decreasing infection, improving wound healing, and accelerating skin barrier recovery.[2,17,22] Moreover, TXA has been widely used in total hip and knee arthroplasty to reduce intraoperative and postoperative blood loss and swelling of the affected limb.[23,9,16] However, no reports have detailed its use in open arthrolysis for the treatment of elbow stiffness. Here, we aimed to determine whether the amount of blood loss will decrease with topical TXA use in patients with elbow joint arthrolysis and whether patient prognosis will increase accordingly.

## Materials and methods

This is a prospective comparative trial of the effect of topical TXA on post-traumatic elbow stiffness in patients treated with open arthrolysis.

### Patients

The study was performed from February 2015 to May 2017, during which 97 cases of elbow stiffness were treated with open arthrolysis. All the recruited patients had elbow stiffness due to elbow trauma or surgery and were treated with open arthrolysis by 2 surgeons. The exclusion criteria were as follows: current medical management of deep vein thrombosis or pulmonary embolism; previous subarachnoid hemorrhage or embolic stroke; liver disease with an abnormal coagulation profile; elbow joint stiffness of nontraumatic causes such as burns, brain trauma, or rheumatoid arthritis; current treatment with oral contraceptive pill or hormone replacement therapy; elbow joint infection history, including bacterial infections and elbow joint tuberculosis; and not less than 24 months of follow-up.[15] Finally, 61 patients were enrolled, all of whom provided written informed consent before surgery. In accordance with a computerized random-number generator, 31 patients were treated with topical TXA intraoperatively after open arthrolysis (group A), whereas the other 30 patients received saline only (group B). The patients' characteristics are shown in Table I. The surgeons and assistants who recorded the data were blinded to the experiment design, and the operation was performed in a double-blind setting.

### Use of TXA

A 100-mL solution containing TXA 1.0 g was prepared prior to wound closure and applied topically twice to the wound by the surgical team. The time of application started on completion of the open arthrolysis and before the termination of the pneumatic tourniquet. At first, we padded 2 gauze pads soaked in TXA solution in the anterior and posterior joint cavity, and then wrapped around a bandage for 5 minutes. The remaining active bleeding was blocked by ligature or electric coagulation. The TXA solution was applied again once the wound was closed and a drainage tube was placed in the joint cavity. We injected the TXA solution in the elbow joint from the drainage tube until backflow was observed, at which time the tube was clamped and kept in place for 3 hours. Unlike in arthroplasty, the joint capsule intravenous (IV) injection method was not used preoperatively because the joint capsule should be excised quickly at the beginning of surgery, and the injected liquid would be sucked immediately by an aspirator.

A saline placebo was applied in the control cases in the same way as the TXA solution. The injected and drainage volumes in both groups were recorded by an assistant who was ignorant of this trial. After the active bleeding was controlled and the wound closed, whether the use of an external fixator was necessary was determined according to whether the elbow joint was stable. The operation time, tourniquet time, and intraoperative blood loss were recorded (Table II).

### Postoperative treatment and rehabilitation exercise

Drainage tubes were kept for 2 or 3 days until the drainage volume was $<30$ mL/d. The drainage volume was recorded by nurses blinded to the experiment. After tube removal, residual hematoma was detected on B-mode ultrasonography at 40° elbow flexion. Postoperatively, the elbow was kept extended overnight with an external fixator or adjustable orthosis, and each patient was encouraged to perform activities, including self- and gravity-assisted hand, wrist, elbow, and shoulder exercises during the daytime for the first several days until the elbow edema diminished. Oral nonsteroidal anti-inflammatory drugs (indomethacin 25 mg) were taken by the patients 3 times a day for 6 weeks to reduce rehabilitation exercise pain. The patients were then asked to increase the time and range of active and passive exercises gradually as tolerable and instructed to alternately sleep with the elbow positioned in as much flexion or extension as possible. After 6 weeks, the external fixator or orthosis was removed. Follow-up assessments, including drainage volume, elbow rotation, elbow motion arc, Mayo Elbow Performance Score, and surgery-related complications were measured and recorded by an assistant blinded to the experiment.

**Table I** Basic information of patients

| Characteristic | Group A | Group B | *P* value |
|---|---|---|---|
| Sex, M/F, n | 20/11 | 16/14 | .38 |
| Age, y, mean ± SD | 40.8 ± 14.2 | 38.2 ± 14.1 | .48 |
| Follow-up time, mo | 26.9 ± 2.8 | 26.2 ± 3.1 | .78 |
| Rotation of elbow | 108 ± 50.1 | 109 ± 49 | .97 |
| Arc of elbow motion | 48 ± 24 | 7 ± 27 | .85 |
| External fixator, yes/no, n | 24/7 | 22/8 | .77 |
| HO (llahi grade), I/II/III/IV, n | 16/5/7/3 | 13/4/8/5 | .81 |
| MEPS | 45.7 ± 6.5 | 44.7± 5.5 | .52 |

*M/F*, male/female; *HO*, heterotopic ossification; *MEPS*, Mayo Elbow Performance Score.
Unless otherwise noted, values are mean ± standard deviation.

## Statistical analyses

The patients' basic information and follow-up results were analyzed with the Fisher exact test using SPSS 20.0 (IBM Corp., Armonk, NY, USA). The categorical outcomes of the 2 groups were compared using a $\chi^2$ test. Significant statistical differences were defined by a $P$ value of $<.05$, the significance level was set as an $\alpha$ value of 5%, and the power was 80%.

## Results

Tourniquet time, operative blood loss, and postoperative drainage volume were significantly lower in the TXA group (group A) than in the control group (group B). However, the ultrasonography after drainage tube removal revealed no significant intergroup difference in hematoma volume (6 ± 5 mL in group A vs. 7 ± 6 mL in group B; Fig. 1). At the final follow-up (2-year), the mean elbow motion arc increased 59° and 61° in groups B and A, respectively. The mean elbow rotation arc, increasing arc, and Mayo Elbow Performance Score improvement did not differ significantly between the groups (Table II). The surgery-related complications in this study included pin track infection, radial or ulnar nerve injury, and instability. Although nerve injury occurred in 5 and 6 patients in groups A and B, respectively, it was not permanent and resolved within 6 months. A pin track infection was observed in 3 and 2 patients in

**Table II** Follow-up results

| Characteristic | Group A | Group B | *P* value |
|---|---|---|---|
| Intraoperative | | | |
| Operation time, min | 101.3 ± 33.0 | 105.0 ± 34.2 | .67 |
| Tourniquet time, min | 30.7 ± 8.87 | 36.1 ± 8.92 | .023 |
| Blood loss, mL | 158 ± 56 | 198 ± 90 | .038 |
| Postoperative | | | |
| Volume of drainage | | | |
| Day 1 | 97 ± 32 | 144 ± 58 | .001 |
| Day 2 | 60 ± 15 | 71 ± 21 | .016 |
| Day 3 | 33 ± 11 | 36 ± 14 | .44 |
| Total | 210 ± 80 | 259 ± 97 | .033 |
| Rotation of elbow | | | |
| 6 weeks | 141 ± 22 | 133 ± 27 | .74 |
| 1 yr | 156 ± 13 | 152 ± 29 | .74 |
| Arc of elbow motion | | | |
| 6 weeks | 103 ± 19 | 102 ± 19 | .21 |
| 1 yr | 111 ± 21 | 113 ± 22 | .81 |
| MEPS | | | |
| 1 yr | 87 ± 9 | 87 ± 11 | .77 |
| Complication, n | 9 | 9 | >.99 |

*MEPS*, Mayo Elbow Performance Score.
Unless otherwise noted, values are mean ± standard deviation.

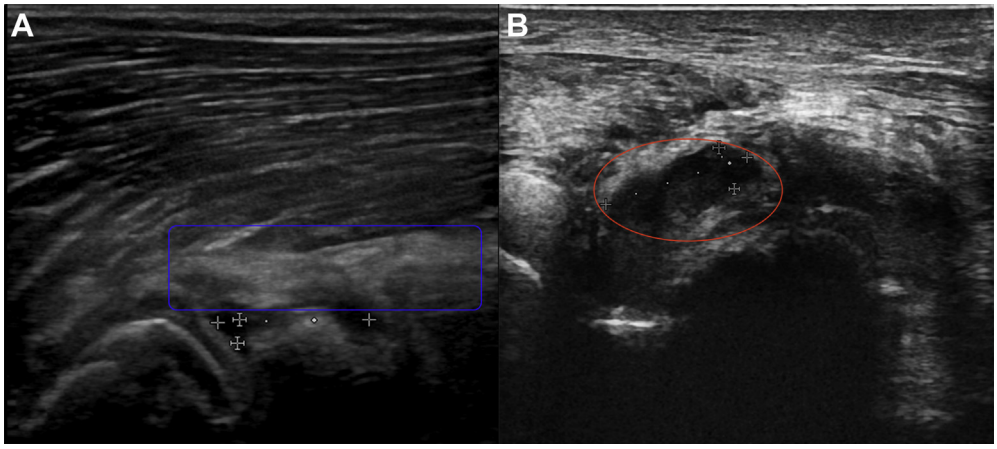


**Figure 1** Each patient underwent B-mode ultrasonography with the elbow at 40° flexion after drainage tube removal; the hematoma volume did not differ significantly between the 2 groups. (**A**) The area of the blue box shows a soft tissue edema. (**B**) The length, width, and thickness (red circle) of the hematoma and residual exudate on ultrasonography in this patient were 12, 8, and 9 mm, respectively; thus, the volume was about 1 mL.

groups A and B, respectively; all healed after external fixator removal. The 1 case of elbow instability in the experimental group resulted in mild post-traumatic osteoarthritis. Recurrent heterotopic ossification occurred in only 1 patient in group B (Table II).

## Discussion

To our knowledge, this is the first study to examine whether TXA use influences the outcomes of elbow joint open arthrolysis. The mean intraoperative blood loss, drainage volume on postoperative days 1 and 2, and the total volume were all better in the experimental group than in the control group, with statistically significant differences. Our results indicate the effectiveness of TXA for hemostasis, confirming the results of other studies.

The methods of TXA administration include IV injection, intramuscular (IM) injection, oral intake, and topical application. Unlike IV and IM injections, topical TXA is used to diminish side effects. Although IV injection, IM injection, and topical administration effectively decrease the amount of blood loss without increasing deep vein thrombosis, IV and IM TXA injections are occasionally related to serious complications such as myocardial infarction, ischemic stroke, neurologic disability, convulsive seizures, and acute renal failure.[18] Moreover, regarding the elbow arthrolysis results, in previous reports, topical usage resulted in less drainage, which decreased the remaining hematoma.[8] In our study, no complications due to TXA use occurred, which also illustrates that the topical use of TXA is both convenient for surgeons and safe for patients.

Improper treatment after elbow joint trauma, excessive elbow joint immobilization time, heterotopic ossification around the joint, and contracture of the elbow joint capsule and soft tissue are the main causes of post-traumatic stiffness.[12,24] Recurrence of heterotopic ossification after open arthrolysis for elbow joint stiffness is also a significant factor of elbow joint stiffness recurrence.[14,20] The stimulating vascular endothelial mesenchymal pathway or mesenchymal stem cells directly derived from blood were stimulated by local osteogenic factors after the formation of local hematoma, and differentiation into osteoblasts is one of the most likely mechanisms for the occurrence of heterotopic ossification.[4,19,21] Thus, bleeding control and hematoma prevention are critical in open arthrolysis for preventing elbow joint stiffness recurrence. However, in our study, 4 patients in group A and 3 in group B had elbow stiffness recurrence, and only 1 patient in group B developed heterotopic ossification after open arthrolysis for elbow joint stiffness. The increases in elbow rotation and motion arc did not differ significantly, and we attribute this to the thorough drainage of congestion. Ultrasonography revealed that the volumes of the residual exudate and hematoma barely differed between the 2 groups after drainage tube removal. Although only 1 case of heterotopic ossification occurred in the 2 groups, it is possible that hematoma formation was associated with elbow motion and subsequent bleeding during the recovery phase.

The limitation of our study is that we did not determine whether hematoma formation could affect the patients' final elbow function. The thorough drainage of congestion perioperatively and postoperatively might have played a significant role in our study. Thus, a retrospective study will be performed in the future. Moreover, the pressure of the bandage at the first TXA use was not measured quantitatively, although different pressures could influence the amount of blood loss.

## Conclusion

The topical use of TXA during surgery in patients treated with elbow joint open arthrolysis could safely reduce blood loss at the early stage. Thus, it could be used as a routine procedure in elbow joint open arthrolysis.

## Disclaimer

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